CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

INCLUDING PRESTRESSED CONCRETE

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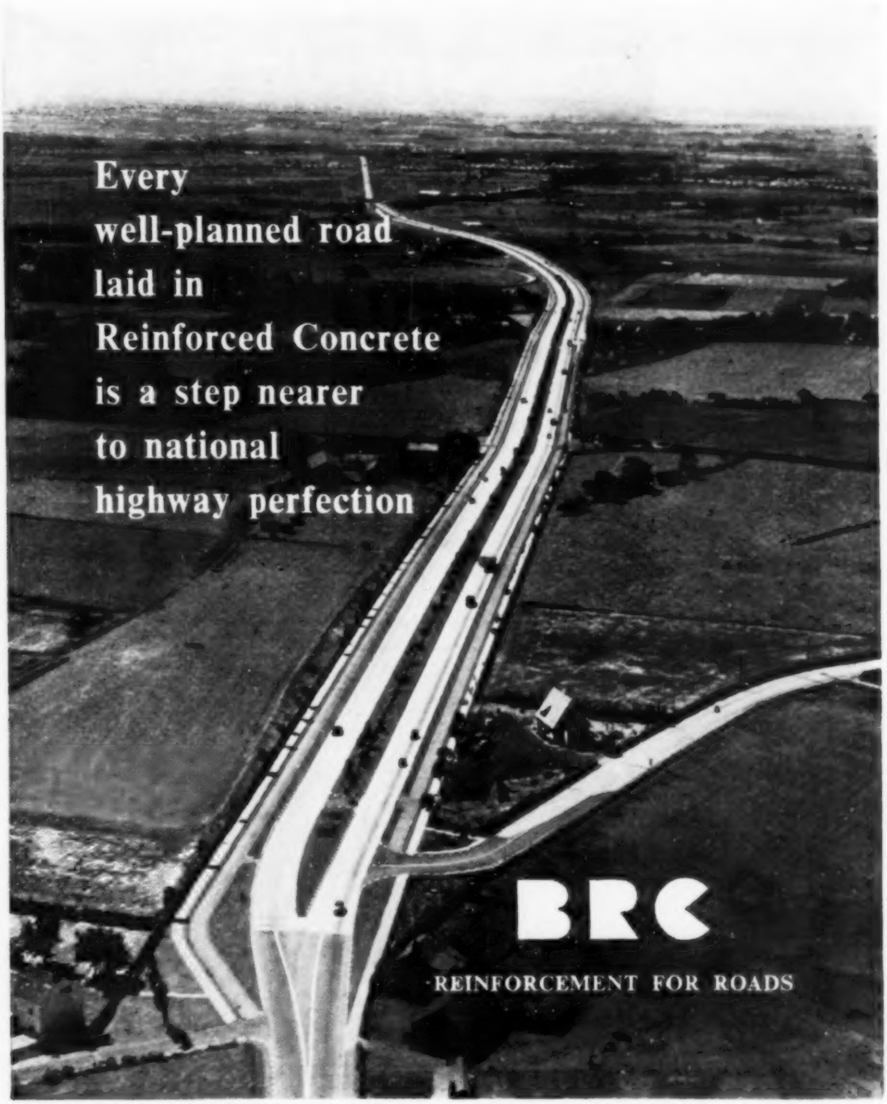

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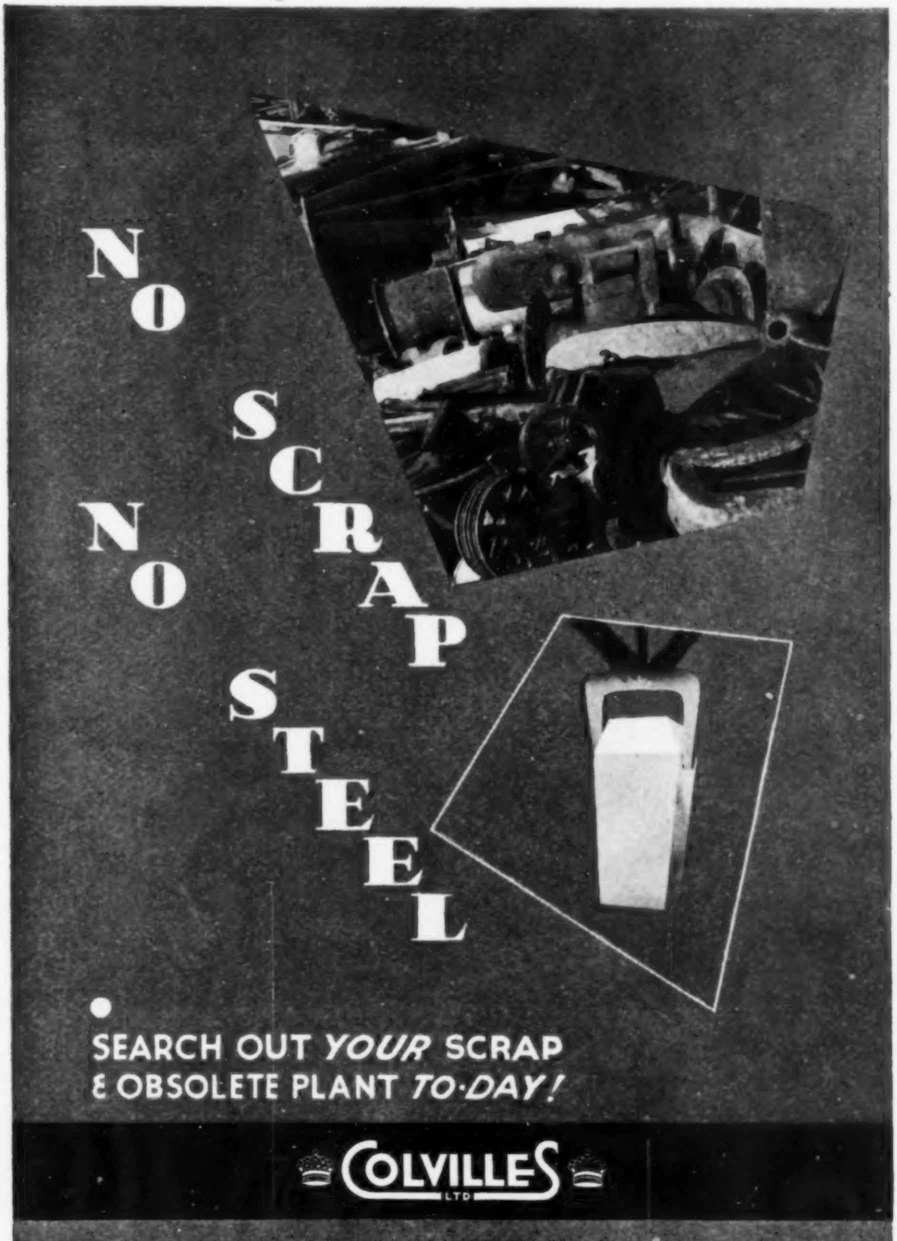
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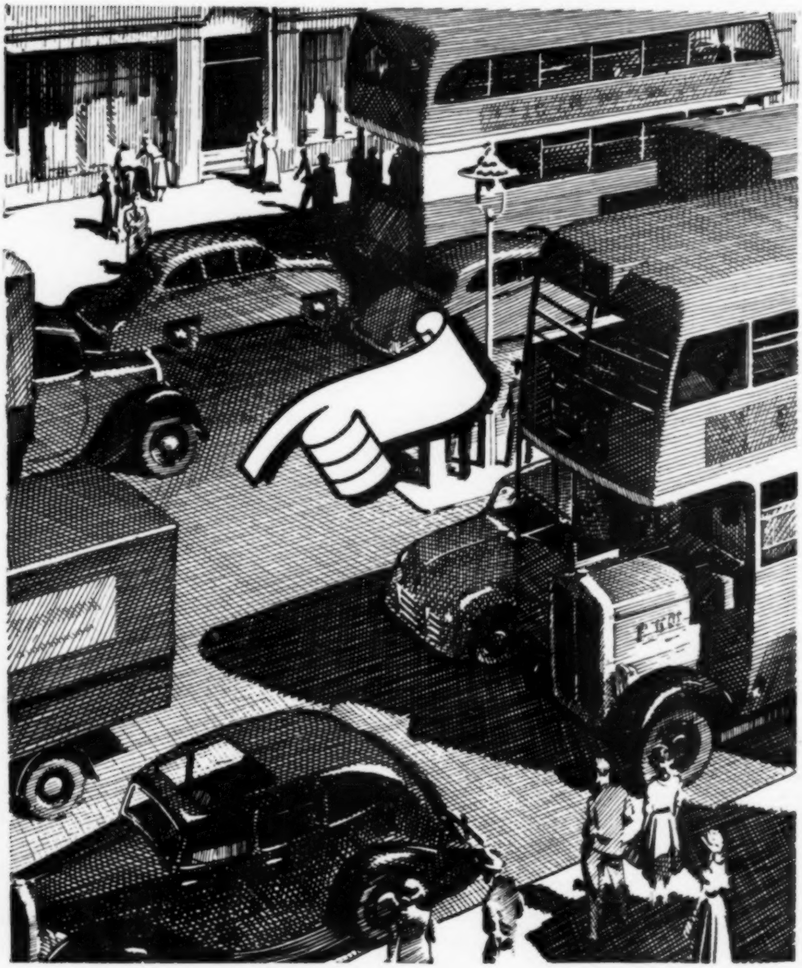

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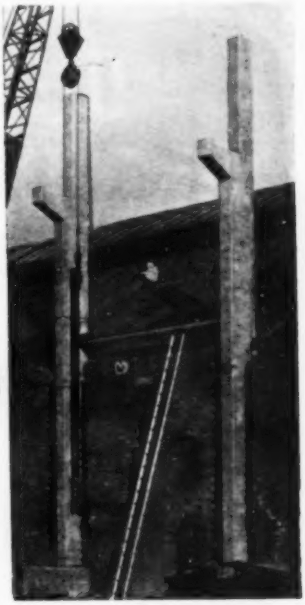

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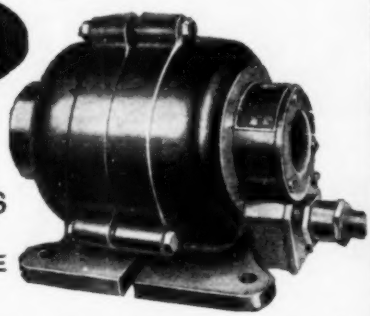

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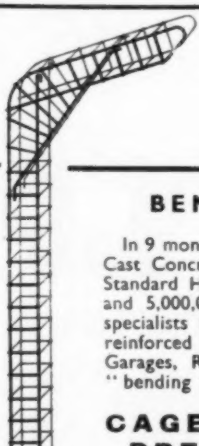

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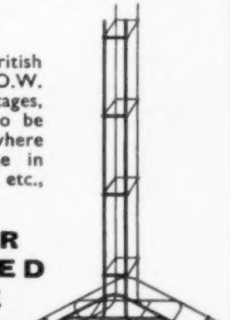

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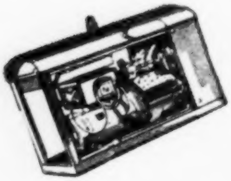

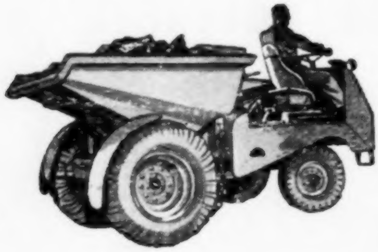

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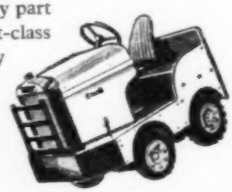

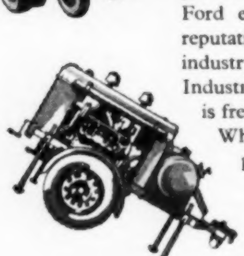

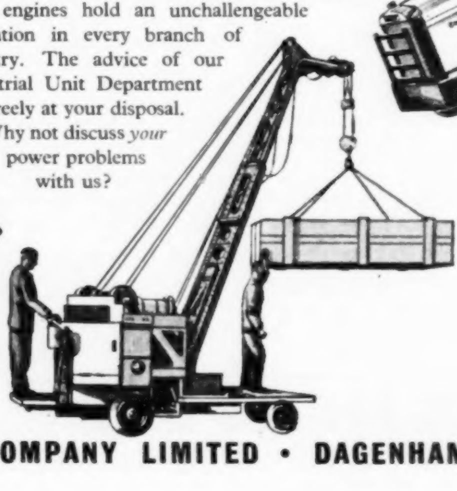

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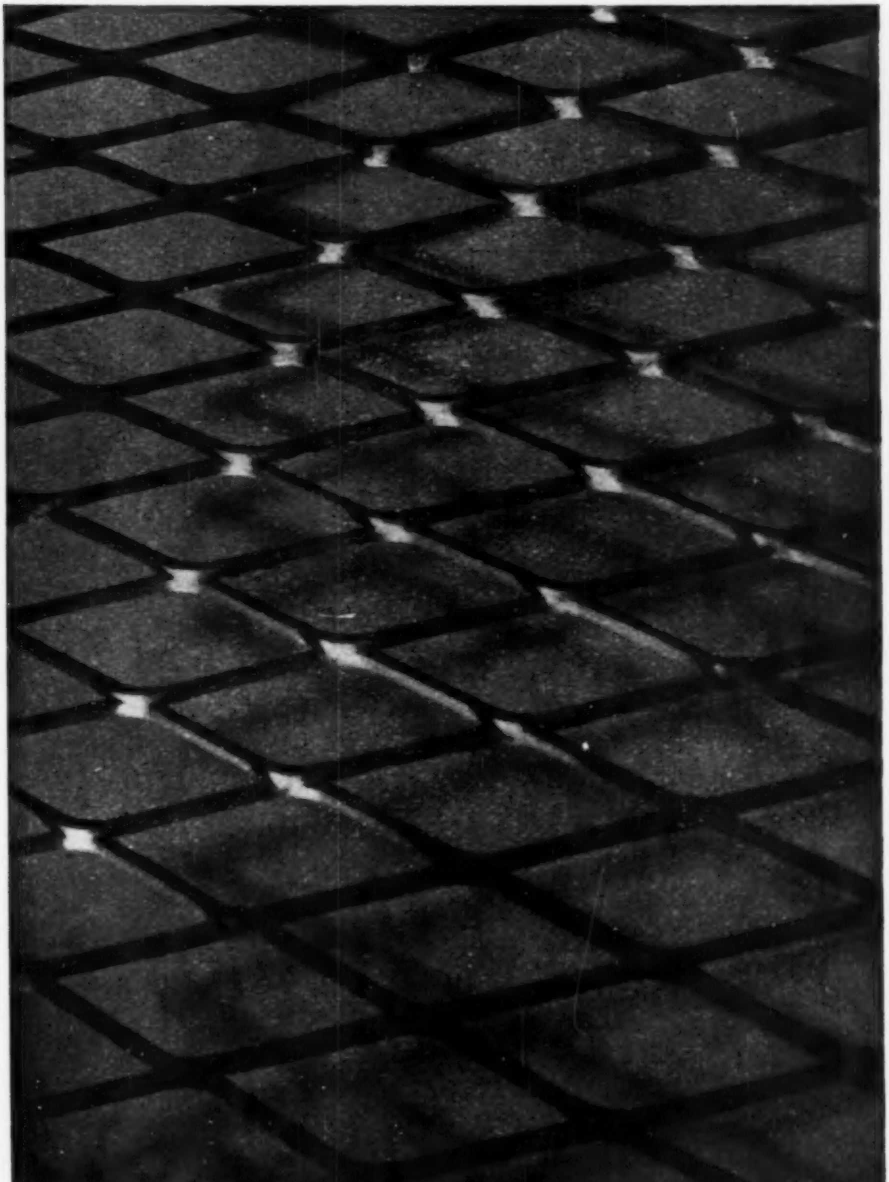

CONCRETE
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Volume XLVII. No. 5. LONDON, MAY, 1952.

EDITORIAL NOTES

Methods of Testing Concrete.

No method of testing materials can be entirely satisfactory when the strength throughout a large mass is assumed to be the same as the strength of small samples subjected to test. This is true in the case of a finished material, but in the present common method of assessing the strength of a mass of concrete in a structure by the strength of small samples taken as the material leaves the mixer we are assuming that samples of a semi-finished product will give a true representation of the properties of the finished product made under different conditions. This can seldom be so. The sample is packed into a small steel mould by a man whose object is to get as high a strength as possible. The remainder of the semi-finished product is shovelled or tipped into shuttering which may be of steel or wood, and consolidated and cured by men who are much less concerned to produce concrete of the highest strength or to simulate on the site the processes used by the man who takes the samples—even if it were possible to do so. The strength of concrete in a structure can be, and generally is, very different from the strength of the test cubes. Also, however carefully materials and water are measured to ensure uniformity in every batch, the differences in the quality of the hardened concrete in various parts of a structure can be, and are, considerable. In a recent case concrete in an important part of a structure had to be removed at great expense because men who were dissatisfied with their working conditions deliberately skimped their work, and most engineers know of cases where batches of inferior concrete have been produced as a result of ignorance or carelessness. Test cubes give an idea of the strength that is possible with the materials used, but are not a guarantee that all of the concrete in a structure will have the same strength as the test cubes. In ground slabs it is possible to drill cores from the finished work, and these give a more reliable indication of the strength of the concrete as laid. It is not possible, however, to take cores from all parts of a structure, and in these circumstances, until a better method is devised, the testing of " works cubes " is used as a guide to the strength of the finished concrete.

This problem has recently been considered by the Committee for Reinforced Concrete in Germany (the Deutscher Ausschuss für Stahlbeton), which has supervised tests of a method devised by Professor Baumann in which a ball operated by a spring is impinged upon the hardened concrete. In a report recently issued, entitled " Die Kugelschlagprüfung von Beton,"* the committee recommends

* Published by Wilhelm Ernst. Berlin. Price 7.50 D.M.

that this method be adopted in place of test cubes. As in the Brinell test, the hardness is measured by the size of a depression made by the blow of a ball on the surface, and this measurement is correlated to the strength of the concrete as shown by actual crushing tests. In the experiments more than seven hundred cubes were made, and these were tested at ages ranging from seven days to fifty-six days after the specimens were cast. The compressive strength of the concrete was plotted against the diameter of the depression made by the ball, and from the results a curve was interpolated representing average values computed from regression equations derived from the theory of probability. In the case of a depression of 5 mm. diameter, the average cube strength of the concrete was found to be 4960 lb. per square inch and the minimum 3820 lb. per square inch. With a depression of 4·5 mm. diameter the average strength was 7700 lb. per square inch and the lowest 6150 lb. per square inch. As would be expected, small variations in the diameter of the depression indicate great differences in the strength of the concrete, and the measurement of the indentation made by the ball must therefore be accurate. Special magnifying glasses permitting readings to one-tenth of a millimetre are recommended for this purpose. The investigations described in the report relate to dense concrete only. The apparatus is 14 in. long and weighs 5½ lb., and can give impacts of 43½ lb. or 10·8 lb. per square inch.

It is much in favour of this method of testing that it can be applied to the hardened concrete in a structure and aims at indicating the actual strength rather than, as in the case of tests on cubes and cylinders, giving an indication of what the strength might be under conditions that cannot be realised in actual work. However, it seems that the difference in strength as shown by this apparatus was about 50 per cent. between the highest and the lowest. This is a greater variation than is common in crushing tests, and may indicate that this impact test is even less reliable than crushing tests. Also, it appears that the tests were made on cubes all of the same size, and no information seems to be available on the effects of the impact on parts of a structure which are thicker or thinner than the cubes tested. This is a matter of major importance, for if the depth of the depression is an indication of the strength of the concrete near the surface only the test may lead to fallacious conclusions. The test can be quickly and cheaply made and applied to many parts of a structure, but unless it indicates the strength of the concrete throughout a structural member it serves no more useful purpose than does the use of a spring-controlled hammer to ascertain whether the concrete is hard enough to allow the removal of shuttering with safety.

For example, the depth of penetration of the ball may depend upon whether or not there is a piece of large aggregate immediately below the point of impact, in which case it might be that the penetration would be less than if there were a greater depth of mortar ; the strength indicated would then depend upon the amount of spading of the concrete against the shuttering. Further, excessive spading or vibration would bring to the surface a rich and strong mortar, and the apparatus might indicate a high-strength concrete although the core might be weak because it has been deprived of cement. The strength of concrete depends primarily upon the strength of the mortar, but it is necessary to be sure that the mortar is of the same strength throughout the concrete. What is needed is a method of test similar to that used by a cook when she plunges a needle into a cake to see if it is properly cooked throughout.

Cooling-water Intake Structure at an Oil Refinery.

By B. H. BROADBENT, B.Sc.(Eng.), A.M.Inst.C.E.

PRESENT conditions add to the numerous questions which have always to be studied in determining the type of construction to be used for a given purpose. The cooling-water intake structure for the Vacuum Oil Company's refinery on the river Thames at Coryton had to be designed for rapid construction at a time when it was almost impossible to obtain a promise of delivery of steel and before the present system of priorities had been introduced. It had originally been proposed

Fig. 1.—Intake Arriving at Coryton.

to construct the intake structure in a cofferdam of steel sheet piling, but due to the depth of water at the river site and the steeply-sloping clay and silt bank this would have been a difficult operation, requiring a considerable quantity of heavy-section piling which seemed unlikely to be available for at least twelve months. A similar difficulty was present in any scheme requiring the large quantity of fabricated steel necessary for a steel caisson. Reinforced concrete, with its relative economy in steel and the versatility with which material in stock can be utilized, offered more promise of a solution of the problem, especially as there could be some pooling of the steel required for this purpose with the large quantities of reinforcement bars already ordered for the construction of the

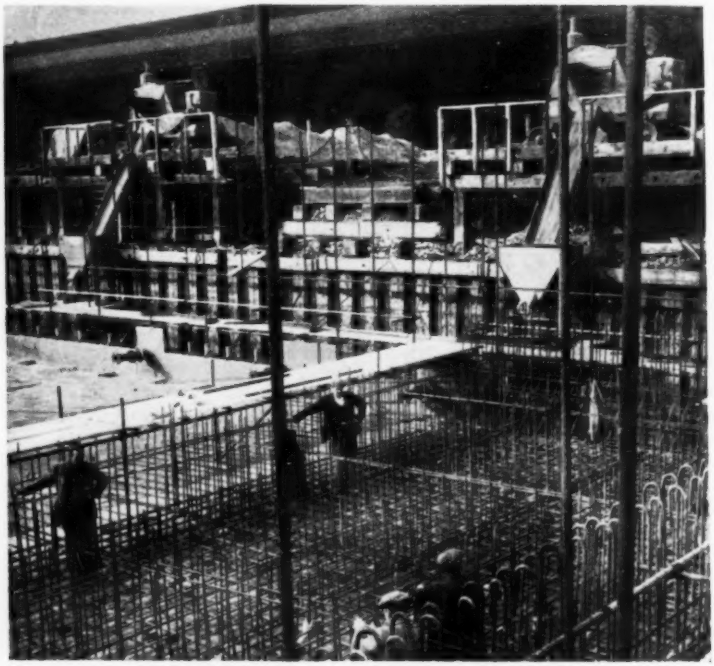


Fig. 2.—Construction at Gravesend to Height of 12 ft. 6 in.

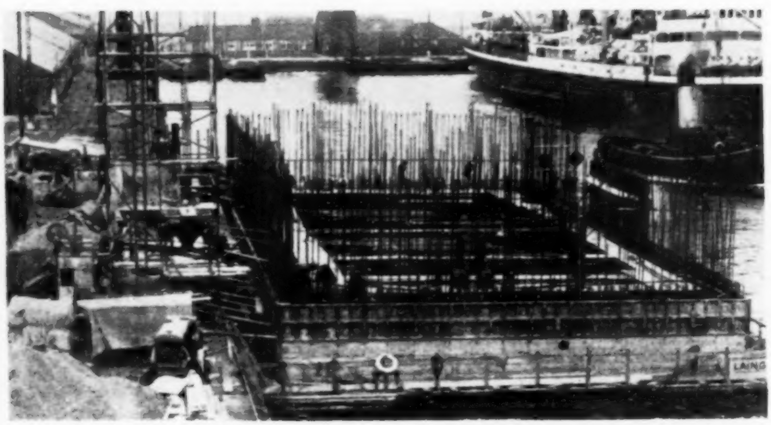


Fig. 3.—Construction at Tilbury to Height of 52 ft. 6 in.

refinery. By close co-ordination between design and construction, also, the sizes of the reinforcement bars could be altered to suit the sizes of bars available at any time. Since steel sheet piling was not available, some form of caisson which could be either lowered from staging over the final site or floated into position seemed likely to be the best solution.

The site of the intake is at an exposed part of the Thames estuary where tidal currents are strong, and construction had to be begun in the autumn and carried on through the winter. Moreover, the bed of the river at the site consists of a thin layer of silty clay overlying exceptionally compact ballast into which it is difficult to drive timber piles to a sufficient depth to ensure lateral stability. The cutting-edge of a caisson would have to be pitched at a depth of about 40 ft. below mean tide level before sinking began, and normal spring tides rise about

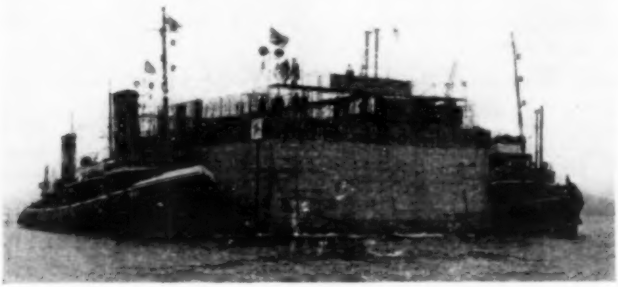


Fig. 4.—Under Tow from Tilbury to Coryton.

8 ft. above the mean. All this made construction on a piled staging undesirable. On the other hand, it was impossible to find a suitable nearby site for constructing the intake structure on land and floating it into position. The whole of the refinery area, as well as a large district behind it, lies below high-water level and is protected by a clay bund which has to be meticulously maintained.

A building site at a greater distance, where construction could proceed unhampered by storms and tides, was therefore sought. As only one structure had to be built it was also desirable to make use of existing facilities as far as possible. A dock was found, near Gravesend, which had been used during the war for building anti-aircraft gun-towers (which were floated into position and sunk in the Thames estuary) and concrete floating dry docks. Here a draught of about 10 ft. was available at high-water spring tides, and the only preparation necessary was to clear the silt which had accumulated since the dock was last used and to construct a temporary dam to keep out the water during building. This dam was constructed of two rows of steel sheet piling, tied together and filled with ballast. In the dock, the floor of the structure was cast on hollow slabs and the external walls, with the necessary internal bracing, were built up to a height of 12 ft. 6 in. (*Fig.* 2). On November 30, 1951, after removal of the temporary dam, the structure was floated at high tide and towed across the river into Tilbury Docks where the Port of London Authority had made a ship's berth

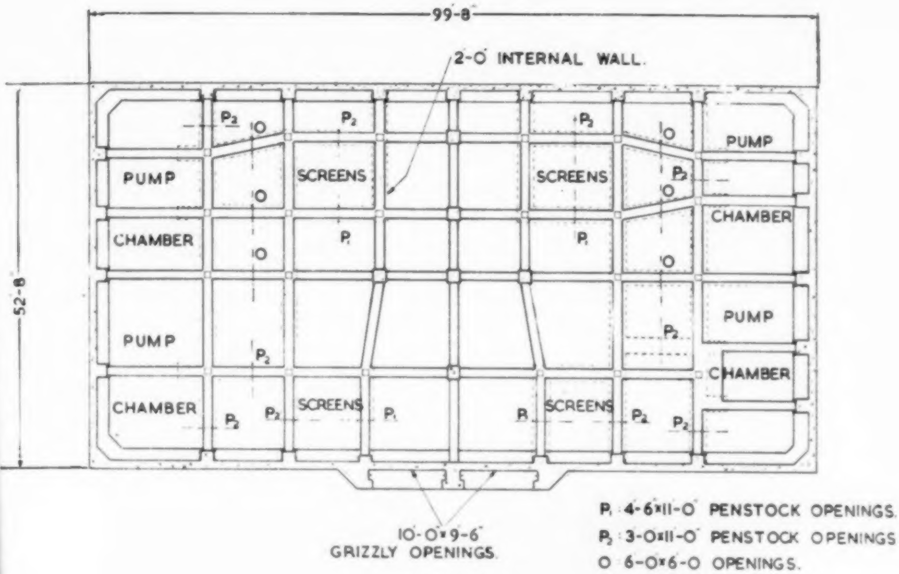


Fig. 5.—Plan.

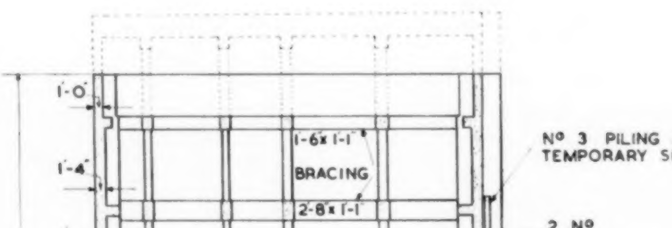


Fig. 6.—Transverse Section.

[Dotted lines indicate walls and deck to be built at Coryton. The ballast is shown hatched in *Fig.* 6.]

available. This berth provided an adequate depth of still water unaffected by tidal variations, and construction was continued afloat (*Fig.* 3) to a total height of 52 ft. 6 in.

Having reached this stage the structure was towed out of Tilbury Docks at high water on the morning of March 6, 1952, and taken down river with the falling tide by four large ships' tugs (*Fig.* 4). A bolster-barge had been moored alongside a group of timber piles to mark the position of the intake, and, with the aid of four wire cables attached to winches on the shore, the tugs brought the structure into position at low water (*Fig.* 1). It was then flooded, through twelve 6-in. valves built into the sides, and sunk on to a level bed which had been prepared by dredging. This rather delicate operation was successfully carried out, the final position being well within the tolerance allowed.

The bed of the river at Coryton has remained stable over a long period with little erosion or deposition, and near the surface there is a deep bed of very compact ballast. A solid foundation on this was preferred to a piled base and, although borings indicated that a suitable base would be found by dredging, provision was made for the possibility of excavating through the floor, if required, and pipes were also installed which could be used for injecting grout under pressure to fill any cavities due to irregularities of the bed.

The depth of water at high tide made it necessary to build a relatively lofty structure, and the high water pressures to be resisted required a fairly strong structure, so that it became difficult to secure adequate stability with a reasonable draught while the structure was afloat. It was decided that the draught must not exceed 30 ft. and the design provided for a draught of 29 ft. 4 in.

The design was complicated as provision had to be made for a wide variety of loadings to which the structure would be subjected at every stage of construction, afloat, and in its permanent position, the total weight had to be strictly limited until the structure was sunk in position, and construction had to be begun as soon as sufficient details for the first stages could be ready. Stability had to be maintained at all stages of construction afloat, and as soon as concrete was placed it became part of the structure and was consequently subjected to stress before the concrete had matured.

The general construction of the intake structure is shown in *Figs.* 5 and 6. The part between the base and the main floor was divided into a number of compartments by longitudinal and cross walls. These compartments were connected by holes through the walls into six groups, each group being served by two 6-in. valves controlling the passage of water through the external walls. In this way water-ballast could be admitted to correct any tendency of the structure to list. A depth of about 2 ft. 6 in. of 1 : 15 concrete was placed in these compartments towards the end of the construction at Tilbury Docks to maintain stability. After sinking at Coryton these compartments were filled with sand and gravel to provide the necessary weight to resist buoyancy.

Between the main floor and the top slab, partition walls will be required in which penstocks will be fixed to control the passage of water to screens and pumps. These will be built with the structure in its final position, as indicated in *Figs.* 5 and 6; they would have added too much weight at a relatively high level if they had been built while the shell was afloat, and a system of concrete struts and columns (*Fig.* 7) was constructed to resist the water pressure on the

shell. The irregular arrangement of these struts was necessary to clear various fittings to be installed, and in order that they might be enclosed as far as possible within the thickness of the final partition walls. At Coryton the structure will be completed by extending the external walls a further 5 ft., building the internal walls, casting the top platform with its various trenches for pipes and cables, and constructing bases for plant.

The water will be admitted from the river through two openings each 10 ft. square in one side wall, provided with heavy sliding steel screens. It was necessary to close these openings temporarily both for floating the structure and to enable work to be carried on below tide level at Coryton, and for this purpose steel sheet piling was used. The tops of the piles project above low-water level to facilitate their final removal.

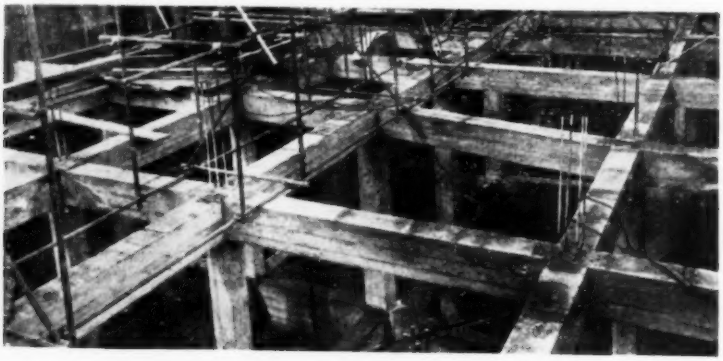


Fig. 7.—Bracing to Resist Water Pressure.

Shuttering for all the walls was of a type which was used successfully for "Phœnix" structures during the war, and its value was again proved. Two lifts of standard panels, 6 ft. long by 2 ft. high, with necessary specials, made of $1\frac{1}{4}$-in. boards on 3-in. by 2-in. frames, were used in a "leap frog" system. The faces were tied together by threaded bars, screwed from either side into nuts welded to a shaped separator and with double nuts outside the shutter framing. *Fig.* 8 illustrates the method of fixing the shutters.

In the dry dock at Gravesend the concrete was mixed in 14/10 drum mixers and delivered by chute to wheelbarrows for distribution to the walls. At Tilbury Docks, in the earlier stages, concrete was wheeled directly from the mixers, water-ballast being pumped into the structure to maintain the top of the walls at an approximately constant level until a height of 30 ft. 6 in. was reached. The water-ballast was then pumped out, and hopper hoists were used for lifting the concrete for the remainder of the walls. This lowering of the structure in the water also greatly reduced the amount of external scaffolding required for lifting the shutters, as it was possible to do this work from a stage floating on oil drums which was incorporated in a timber fender placed to protect the structure from damage by the craft using the dock.

The proportions of the concrete generally were 3·66 cu. ft. of $\frac{3}{4}$ in. to $\frac{3}{16}$ in.

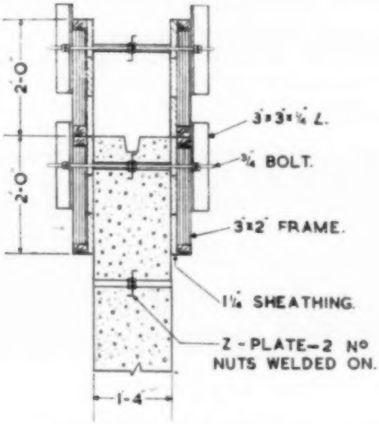


Fig. 8.—Cross Section of Typical Shuttering.

stone, 2·65 cu. ft. of sand, and 112 lb. of cement, and all concrete was vibrated with poker vibrators. During frosty weather the aggregates were steam-heated and, in certain parts which were subjected to early stressing, Portland cement containing calcium chloride was used. Test cubes were made and crushed at regular intervals. The average crushing strength of cubes was 6150 lb. per square inch at 28 days.

The cost of the work has not differed greatly from the estimated cost of more conventional methods, but a saving of time of at least six months has been achieved in spite of some delays in obtaining steel reinforcement. Messrs. John Laing & Son, Ltd., the contractors for the foundations and civil engineering works at the refinery have, in conjunction with the Lummus Company of New York and London (the main contractors to the Vacuum Oil Co.), been responsible for the planning and construction of this structure ; Mr. D. N. Mitchell, A.M.Inst.C.E.,was in charge of the detailed design work.

Civil Engineering in the British Colonies.

The Institution of Civil Engineers is holding the third conference on Civil Engineering in the Colonies in London from June 16 to 20. These conferences are intended to cater for the Colonial Engineering Service and of others engaged in civil engineering work in the British Colonies. Attendance at the conference is not confined to members of the Institution, and non-members may attend by making application to the Institution. The conference comprises visits to works and technical sessions at which papers will be discussed on road research, railways, water power, and water supply. Further details may be had from the Secretary, Institution of Civil Engineers, Great George Street, London, S.W.1.

Shell-roof Hangars of 333-ft. Span.

THE roofs of two new hangars of shell construction at Marseilles are described in a recent number of "Le Genie Civil". Each hangar is 333 ft. wide and 193 ft. long, and has a clear height of 62 ft. below the ties at the entrance. The roofs are reinforced concrete parabolic vaults each comprising six secondary vaults 32 ft. wide and about 7 ft. high. The thickness of the shell is generally 2⅜ in. The total height of the structure is about 107 ft. The ties, which are suspended from the vaults at about 33 ft. centres, are of prestressed concrete. A novel feature of the construction is that each roof was constructed on the ground (*Fig.* 1) and then raised on jacks to its permanent level (*Fig.* 2). Sixteen 300-tons jacks and two 100-tons jacks were used, and upward movement was about 3 ft. daily.

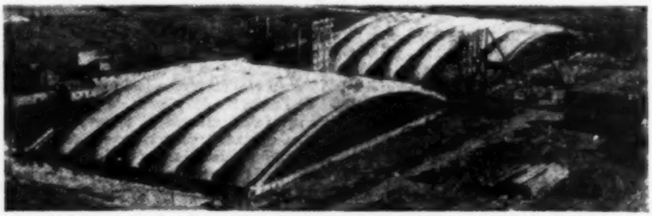


Fig. 1.

Fig. 2.

The Design of Simple and Composite Prestressed Concrete Beams.

By E. W. BENNETT, M.Sc., A.M.Inst.C.E.

THE ultimate moment of resistance of a prestressed concrete beam is governed by the area and position of the tensioned and untensioned wires in the tensile zone, provided that the area of the concrete in compression is sufficient to ensure that failure occurs by extension or fracture of the steel. The working stresses in the concrete, however, depend on the shape and size of the beam and the magnitude and position of the prestressing force. These factors are taken into account in the simple method described of designing symmetrical or unsymmetrical prestressed concrete I-beams and beams made of precast and cast-in-situ parts. A consideration of the ultimate moment of resistance and the factor of safety of prestressed concrete beams, and another method of designing unsymmetrical sections, were given by Dr. P. W. Abeles in this journal for October, 1951, and March, 1952.

Ordinary Beams.

Formulæ for the section moduli Z_1 and Z_2 related to the bottom and top respectively of an unsymmetrical section and obtained from the equations given by Dr. Abeles are

$$Z_1 > \frac{M_w - R_0 M_e}{R_0 f_{ct} + f_{tw}}; \quad Z_2 > \frac{M_w - R_0 M_e}{R_0 f_{2t(lim.)} + f_{cw}} \qquad (1)$$

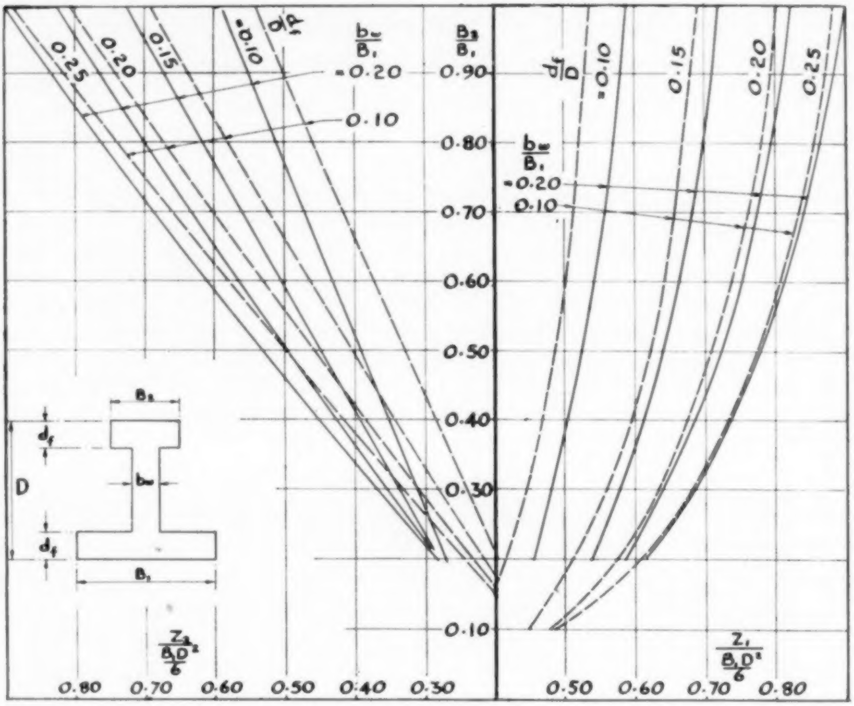
The notation is shown in *Fig.* 1, or is as follows: M_w, bending moment due to the working load; R_0, reduction of prestress in course of time; f_{ct}, f_{cw}, compressive stress permitted when the concrete is put into compression and at working load respectively; f_{tw}, tensile stress permitted in the concrete at working load. Other symbols are explained in the text.

The bending moment M_e is the minimum bending moment due to the weight of the beam that may occur during its manufacture, transport and erection. If the beam is always upright and supported at its ends $M_e = M_s$ for the section at midspan, and $M_e = -M_s$ if the beam is suspended from the midpoint while upright or supported at its ends while inverted. If the beam is slung at the first and third quarter-points $M_e = -0{\cdot}25 M_s$ at the slinging points, and zero at midspan.

Having calculated from (1) the minimum section moduli required, a cross section having these values can be designed fairly accurately at the first attempt by using the chart in *Fig.* 1, which gives the ratios of Z_1 and Z_2 to the section modulus of the circumscribing rectangle for unsymmetrical sections of various proportions. The section selected will generally have values of Z_1 and Z_2 slightly greater than the minima, and the prestress f_{1t} and f_{2t} at the bottom and top of the beam at the time the compression is transmitted to the concrete must be between the limits

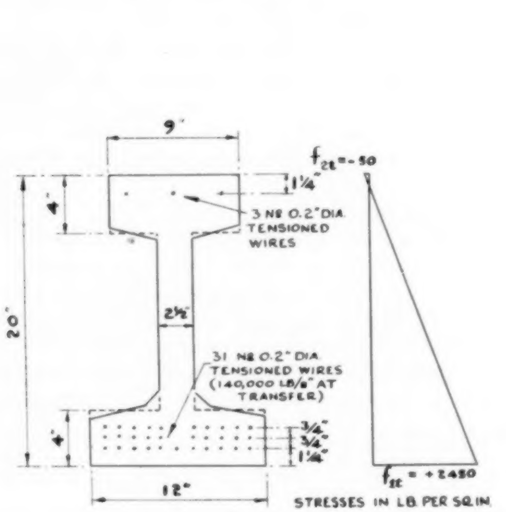
$$\frac{M_w}{R_0 Z_1} - \frac{f_{tw}}{R_0} < f_{1t} < f_{ct} + \frac{M_e}{Z_1}; \text{ and } -\frac{M_e}{Z_2} - f_{2t(lim.)} < f_{2t} < \frac{f_{cw}}{R_0} - \frac{M_w}{R_0 Z_2} \qquad (2)$$

The formulæ for the magnitude $\bar{P}_t$ and eccentricity $\bar{e}$ of the resultant pre-



$\frac{d_f}{D}$ = 0.10
0.15
0.20
0.25
$\frac{b_w}{B_1}$ = 0.20
0.10
$\frac{B_2}{B_1}$
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.10
$\frac{Z_2}{\frac{B_1D^2}{6}}$
$\frac{Z_1}{\frac{B_1D^2}{6}}$
0.80 0.70 0.60 0.50 0.40 0.30
0.50 0.60 0.70 0.80
B_2
d_f
D
b_w
B_1

Fig. 1.



9"
f_{2t} = -50
1¼"
4"
3 Nº 0.2" DIA. TENSIONED WIRES
20"
2½"
31 Nº 0.2" DIA. TENSIONED WIRES (140,000 LB/□" AT TRANSFER)
4"
¾"
¾"
1¼"
12"
f_{1t} = +2480
STRESSES IN LB. PER SQ. IN.

Fig. 2.

stressing force derived from the basic equations for compression and bending of a homogeneous section of area A are

$$\bar{P}_t = \frac{A(f_{1t}Z_1 + f_{2t}Z_2)}{Z_1 + Z_2}, \quad \bar{e}_s = \frac{Z_1 Z_2 (f_{1t} - f_{2t})}{A(f_{1t}Z_2 + f_{2t}Z_1)} \quad . \quad . \quad (3)$$

The eccentricity $\bar{e}_s$ is measured from the centroid of the section, and is positive if below the centroid. It is not implied that all the wires must be placed with an eccentricity $\bar{e}_s$. To obtain the greatest resistance to failure it is necessary to place as many wires as possible near the bottom of the section, balanced by a smaller number near the top. If $\bar{N}$ is the total number of wires and the eccentricity of the bottom and top groups is e_s and e_s' respectively, then N', the number of wires required in the top group, is given by

$$N' = \frac{\bar{N}(e_s - \bar{e}_s)}{e_s + e_s'} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Example No. 1.—Design a beam with a maximum breadth of 12 in. and a depth not exceeding 20 in. to resist a bending moment at working load of 1,600,000 in.-lb. Assume that $M_c = 0$ during erection.

The permissible compressive and tensile stresses in the concrete when it is first compressed are 2500 lb. and 100 lb. per square inch, and at working load 3000 lb. and 500 lb. per square inch, respectively. Assume that $R_0 = 0{\cdot}85$. From (1):

$$Z_1 > \frac{1{,}600{,}000 - 0}{(0{\cdot}85 \times 2500) + 500} > 610 \text{ in.}^3, \text{ and } Z_2 > \frac{1{,}600{,}000 - 0}{(0{\cdot}85 \times 100) + 3000} > 519 \text{ in.}^3.$$

The section-modulus ratio for Z_1 is $\frac{610 \times 6}{12 \times 20^2} = 0{\cdot}76$; for Z_2 it is $\frac{519 \times 6}{12 \times 20^2} = 0{\cdot}65$.

From *Fig.* 1 slightly greater values are obtained if $\frac{d_f}{D} = 0{\cdot}20$, $\frac{b_w}{B_1} = 0{\cdot}20$, and $\frac{B_2}{B_1} = 0{\cdot}75$. The dimensions of a suitable section are therefore as in *Fig.* 2, the properties of this section being: Z_1, 628 in.^{3}; Z_2, 532 in.^{3}; A, 114 in.^{2}; position of centroid 9·18 in. from the bottom. Hence $e_s = 9{\cdot}18 - 2{\cdot}0 = 7{\cdot}18$ in., and $e_s' = 20 - 9{\cdot}18 - 1{\cdot}25 = 9{\cdot}57$ in.

From (2), $\frac{1{,}600{,}000}{0{\cdot}85 \times 628} - \frac{500}{0{\cdot}85} < f_{1t} < 2500 + 0$; therefore $2412 < f_{1t} < 2500$.

From (2), $0 - 100 < f_{2t} < \frac{3000}{0{\cdot}85} - \frac{1{,}600{,}000}{0{\cdot}85 \times 532}$; therefore $-100 < f_{2t} < -10$.

Suitable values of the prestress between these limits are $f_{1t} = 2450$ lb. per square inch and $f_{2t} = -50$ lb. per square inch. From (3),

$$\bar{P}_t = \frac{114[(2450 \times 628) - (50 \times 532)]}{628 + 532} = 149{,}000 \text{ lb.},$$

which can be provided by 34 0·2-in. diameter wires with a stress of 140,000 lb. per square inch when the concrete is put into compression.

From (3), $$\bar{e}_s = \frac{628 \times 532[2450 - (-50)]}{114[(628 \times -50) + (532 \times 2450)]} = 5{\cdot}75 \text{ in.}$$

From (4), $N' = \dfrac{34(7{\cdot}18 - 5{\cdot}75)}{7{\cdot}18 + 9{\cdot}61} = 2{\cdot}90,$

that is three wires should be in the top and 31 wires in the bottom, which when arranged as in *Fig.* 2 have an eccentricity $\bar{e}_s$ of 5·72 in.

Composite Beams.

The following notation is used. Z'_1 and Z'_2, section moduli of composite section related to bottom and top respectively of the precast beam; Z'_3 and Z'_4, section moduli of composite section related to bottom and top respectively of the cast-in-situ concrete; f'_{cw} and f'_{tw}, permissible compressive and tensile stresses respectively in the cast-in-situ concrete at working load; M, bending moment applied to the precast beam, acting alone, due to its own weight and the weight of the wet cast-in-situ concrete; M', additional bending moment applied after the cast-in-situ concrete has hardened and acts with the precast beam as a composite member.

For the bottom of the beam the basic conditions are

$$f_{1t} - \frac{M_c}{Z_1} < f_{ct}, \text{ and } R_0 f_{1t} - \frac{M}{Z_1} - \frac{M'}{Z'_1} > -f_{tw}.$$

Attention must be paid to the signs f_{ct}, f_{cw}, $f_{2t(lim.)}$, and f_{tw} being positive. From these expressions and similar expressions for the top of the precast beam and the top and bottom of the cast-in-situ concrete:

$$\left.\begin{aligned} Z'_1 &> \frac{Z_1 M'}{Z_1(R_0 f_{ct} + f_{tw}) - (M - R_0 M_c)}; & Z'_3 &> \frac{M'}{f'_{tw}}. \\ Z'_2 &> \frac{Z_2 M'}{Z_2(f_{cw} + R_0 f_{2t(lim.)}) - (M - R_0 M_c)}; & Z'_4 &> \frac{M'}{f'_{cw}}. \end{aligned}\right\} \quad . \quad . \quad (5)$$

Formulæ (1), which gives the minimum moduli for an ordinary beam, are replaced by formulæ (5) relating Z_1 and Z_2 to Z'_1 and Z'_2, the values of which can be determined when Z_1 and Z_2 are known, such as is the case when calculating the required size of a composite section containing a precast beam of known size.

In some cases there may be conditions governing the stresses due to dead load or live load, for example f_{tw} may be zero due to the dead load and 500 lb. per square inch due to the total load. In such cases formulæ (5) may have to be solved separately for each condition and the section designed to give a modulus not less than the greatest value of Z'. In other cases the overall dimensions of the composite section may be fixed, and it is then necessary to calculate the size of the precast beam required, for which purpose formulæ (5) are more conveniently expressed thus:

$$Z_1 > \frac{Z'_1(M - R_0 M_c)}{Z'_1(R_0 f_{ct} + f_{tw}) - M'}; \quad Z_2 > \frac{Z'_2(M - R_0 M_c)}{Z'_2(f_{cw} + f_{2t(lim.)}) - M'} \quad . \quad (6)$$

The expressions for the stresses (f_{1t} and f_{2t}) at the bottom and the top of the precast beam when the concrete is put into compression, that is " at transfer," are

$$\left.\begin{aligned} &\frac{M}{R_0 Z_1} + \frac{M'}{R_0 Z'_1} - \frac{f_{tw}}{R_0} < f_{1t} < \frac{M_c}{Z_1} + f_{ct}; \\ \text{and } &-\frac{M_c}{Z_2} - f_{2t(lim.)} < f_{2t} < -\frac{M}{R_0 Z_2} - \frac{M'}{R_0 Z'_2} + \frac{f_{cw}}{R_0} \end{aligned}\right\} \quad . \quad . \quad (7)$$

When the required prestress has been calculated, the number and position of the wires in the precast beam can be calculated from (3) and (4) as for an ordinary beam.

EXAMPLE No. 2.—The thickness of the cast-in-situ slab is to be determined if a 9-in. by 3-in. rectangular precast beam is incorporated in a composite tee-section 15 in. wide which is to carry a uniformly-distributed load of 135 lb. per square foot, the span being 20 ft. The wires required in the precast beam are also to be determined. The permissible compressive stresses in cast-in-situ and precast concrete are 1000 lb. and 3000 lb. per square inch respectively. There must be no tensile stress when the concrete is put into compression, nor due to the working load. Assume that R_0 is 0·85 and that the precast beam may be handled in any position.

$M_c = -\left(\frac{9 \times 3}{144} \times 150\right)\left(\frac{20^2 \times 12}{8}\right) = -16{,}800$ in.-lb. Assuming that the weight of the composite beam is 45 lb. per foot, $M = 45 \times \frac{20^2}{8} \times 12 = 27{,}000$ in.-lb., and $M' = \left(135 \times \frac{15}{12}\right)\left(\frac{20^2}{8} \times 12\right) = 102{,}000$ in.-lb.

$$Z_1 = Z_2 = \frac{3 \times 9^2}{6} = 40{\cdot}5 \text{ in.}^3 \quad \text{From formulæ (5)}$$

$$Z'_1 > \frac{40{\cdot}5 \times 102{,}000}{40{\cdot}5[(0{\cdot}85 \times 3000) + 0] - [27{,}000 + (0{\cdot}85 \times 16{,}800)]} > 67{\cdot}1 \text{ in.}^3$$

$$Z'_2 > \frac{40{\cdot}5 \times 102{,}000}{40{\cdot}5(3000 + 0) - [27{,}000 + (0{\cdot}85 \times 16{,}800)]} > 51{\cdot}5 \text{ in.}^3$$

$$Z'_4 > \frac{102{,}000}{1000} > 102 \text{ in.}^3$$

The ratios of the section moduli vary according to the overall depth of the beam, and several trials should be made. With a depth of 10 in. the ratios are 0·27 for Z'_1 and 0·41 for Z'_4. From *Fig.* 1 the section in *Fig.* 3 may be selected, for which the section moduli are Z'_1, 68 in.^{3}; Z'_2, 156 in.^{3}; and Z'_4, 114 in.^{3}

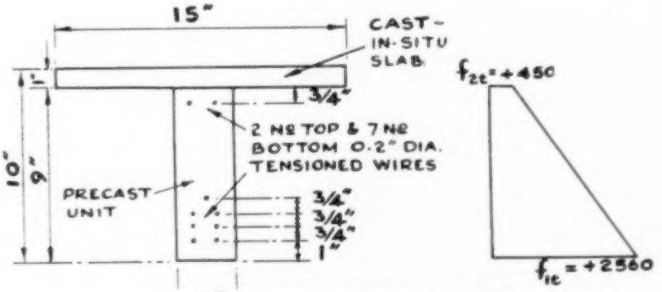


Fig. 3.

The limits of the prestress as given by (7) are

$$\frac{27{,}000}{0\cdot85 \times 40\cdot5} + \frac{102{,}000}{0\cdot85 \times 68} - 0 < f_{1t} < -\frac{16{,}800}{40\cdot5} + 3000\,;$$

that is $2550 < f_{1t} < 2585$ lb. per square inch.

$$+\frac{16{,}800}{40\cdot5} - 0 < f_{2t} < -\frac{27{,}000}{0\cdot85 \times 40\cdot5} - \frac{102{,}000}{0\cdot85 \times 156} + \frac{3000}{0\cdot85}\,;$$

that is $415 < f_{2t} < 1975$ lb. per square inch.
Selecting $f_{1t} = 2560$ lb. and $f_{2t} = 450$ lb. per square inch and substituting in (3), $\bar{P}_t$ is 40,600 lb., which is provided by nine 0·2-in. wires at a stress of 140,000 lb. per square inch; $\bar{e}_s = 1\cdot05$ in. Therefore $e_s = 4\cdot50 - 1\cdot75 = 2\cdot75$ in., and $e_s' = 4\cdot50 - 0\cdot75 = 3\cdot75$ in. From (4), N' is 2·36; two wires are therefore placed at the top and seven at the bottom of the beam.

EXAMPLE NO. 3.—It is required to design a precast beam 20 in. deep to be used in a rectangular composite beam 24 in. deep and 12 in. wide. The bending moment M' to be resisted is 1,255,000 in.-lb. and the span is 44 ft. The permissible stresses in the precast concrete are as in Example No. 1, and the compressive stress in the cast-in-situ concrete must not exceed 1200 lb. per square inch.

$$M = \left(\frac{24 \times 12}{144} \times 150\right)\left(\frac{44^2}{8} \times 12\right) = 870{,}000 \text{ in.-lb.}$$

$$Z_1' = Z_4' = \frac{12 \times 24^2}{6} = 1152 \text{ in.}^3\,; \quad Z_2' = 1152 \times \frac{12}{8} = 1728 \text{ in.}^3$$

Fig. 4.

From formulæ (6)

$$Z_1 > \frac{1152(870{,}000 - 0)}{1152[(0\cdot85 \times 2500) + 500] - 1{,}255{,}000} > 565 \text{ in.}^3$$

$$Z_2 > \frac{1728(870{,}000 - 0)}{1728[3000 + (0\cdot85 \times 100)] - 1{,}255{,}000} > 368 \text{ in.}^3$$

From formula (5),

$$Z_4' > \frac{1{,}255{,}000}{1200} > 1045 \text{ in.}^3$$

Since $\frac{6}{12 \times 20^2} = \frac{1}{800}$, the ratios of the section moduli are $\frac{565}{800} = 0\cdot71$ for Z_1, and $\frac{368}{800} = 0\cdot46$ for Z_2. From *Fig.* 1 the values $\frac{d_f}{D} = 0\cdot20$, $\frac{b_w}{B_1} = 0\cdot20$, and $\frac{B_2}{B_1} = 0\cdot50$ give ratios of 0·72 and 0·49 respectively. Hence the dimensions of the section may be as in *Fig.* 4. The accurate section moduli are $Z_1 = 579$ in.^{3} and $Z_2 = 395$ in.^{3} The area A is 102 in.^{2} and the centroid is 8·11 in. from the bottom, so that $e_s = 8\cdot11 - 1\cdot75 = 6\cdot36$ in. and $e_s' = 20\cdot0 - 8\cdot11 - 2\cdot0 = 9\cdot89$ in. From formulæ (7), suitable values of the prestress when the concrete is put into compression are $f_{1t} = 2500$ lb. per square inch and $f_{2t} = 0$. From formulæ (3), and (4), $\bar{P}_t$ is 145,000 lb., which is provided by thirty-three 0·2-in. wires, $\bar{e}_s = 3\cdot87$ in., and $N' = 5\cdot06$. Therefore there should be five wires at the top and twenty-eight at the bottom as in *Fig.* 4.

Book Reviews.

"Coast Erosion and Protection." By R. R. Minikin. (London: Chapman & Hall, Ltd. Price 30s.)

THIS book is useful to engineers concerned with either new work or the maintenance of existing work bordering on the open sea. The illustrations and examples are primarily taken from Britain and the near-by coastline of the Continent, but the author's opinions and comments, even if in some cases controversial, are well explained and of wide application. The book gives hardly any formulæ or analytical treatment of wave action, littoral drift, or the constructional work of coast protection; it is primarily descriptive, supplemented by constructive criticism. It is easy to read, and illustrated by some 200 photographs and diagrams. This subject has been only scantily treated in recent years, and the history of coast erosion and protection in some areas indicates that more information cannot be superfluous. The omission of references or a bibliography could well be rectified should a later edition be printed, so that readers will be guided to the source of further information on the problems and examples dealt with by the author.—D. L.

"System of Tables for Quick and Accurate Solving of any Continuous Beam." By A. P. Skayannis. 1949. (London: Lange, Maxwell & Springer. Price 21s.)

THIS is an English translation of a booklet originally published in the Greek language. Starting with a known condition at the left-hand end of a series of spans, the table or graph is used to calculate successive "fixed point positions" at the left end of each span. The operation is repeated from the right-hand end of the series of spans. Taking each loaded span separately, by using one of the tables, from the left and right "fixed point positions" are obtained the left and right support moments. The resultant support moments may then be obtained by adding the loads on each span.

If the words "degrees of fixity" are substituted for "fixed point positions"

the method seems to be one which has been in use in this country for more than ten years, and which is explained in relation to beams and frames, with "short-cut" solutions for special cases, in a book entitled "Continuous Beam Structures: The Degree of Fixity Method" by E. Shepley. For those who prefer tables to graphs, these tables are immediately adaptable to the degree of fixity method by the simple conversion $a = \frac{f}{f+2}$. The tables are clearly printed and deal with all cases of uniform and concentrated loading on any system of continuous prismatic spans.

"Anschautiche Verfahren zur Berechnung von Durchlaufbelken und Rahmen" (Ausgleichverfahren). By R. v. Halasz. (Berlin: Wilhelm Ernst & Sohn. 1951. Price 31.50 D.M.)

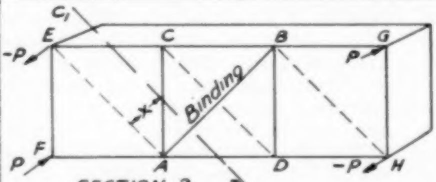
METHODS of calculation of continuous beams and frames by the dispersal of residual fixity moments through successive approximations where the same routine, which is largely self-checking, applies to all types of structures, are, according to the author, being widely adopted on the Continent. It is claimed that much of the arithmetical work can be done by partly-trained staff under the supervision of an experienced engineer. The author gives a summary of the methods originated by Professor Hardy Cross, and their use is illustrated by examples. However, in the method suggested great care must be taken in establishing the correct values of moments and forces in complicated frames subject to sway, and under such conditions it is likely that some of the more familiar methods give quicker results. Many useful diagrams are given for the calculation of beams with haunches at one or both supports, and of beams having varying moment of inertia throughout. Values of the support moments for uniformly, partially, and fully distributed loads are given, and for concentrated loads in any position suitable for the construction of influence lines. Diagrams are also given for stiffness and dispersal coefficients. With these data the method can be readily applied to beams of varying moment of inertia without much extra work.

Design of a Bow Girder.

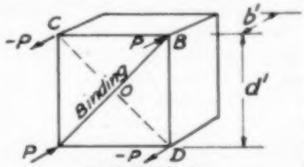
IN response to inquiries regarding the formulæ given in the article in our February number on "The Design of an Unusual Bow Girder", in which spiral reinforcement was used to resist torsion, the author of the article, Mr. V. A. Morgan, M.Eng., has prepared the notes on the facing page.

The concrete, as well as the binding wire, resists the shearing force, which is greatest at the centre of the longer side and less at the shorter side. However, after the concrete has cracked the variation of stress in the uncracked concrete is not the same as in the steel binding wire. Mr. F. B. Seely, in "Advanced Strength of Materials", assumes a rather approximate parabolic variation with a maximum stress of 1·5 times the average as against $\sqrt{2}$ times assumed by Rausch, whereas the solution derived by St. Venant has a much wider variation and is much more related to the results of experiments. The much simpler formula for s_1 given in the article gives results which are almost identical with St. Venant's within the common range of d/b.

It can be shown that the effect of torsion is to twist the top of the beam outwards and away from the centre of the curve. This can be proved by substituting the values of M_K, W_F, and h_F in equation (2a) in the article for the torsion in the straight part BP of the beam. Inward twisting is caused by the load W_F acting at an eccentricity h_F, but $\frac{M_K}{\sqrt{2}}$, causing outward twisting, is greater than the inward torsional moment; hence the top of the beam tends to twist outwards and away from the centre of curvature. A similar result for the torsion acting on the curved part is obtained by substitution in equation (2).



SECTION 2



SECTION 1

To show that the bending moment is uniform along binding wire AB.

FOR CENTRAL SECTION 1:

Loads P acting at A and B produce a moment on the fulcrum diagonal CD which causes a tensile stress in the binding wire at O, which as the tensile strength of the concrete is neglected, is resisted by the binding, the moment being $\frac{Pd'}{\sqrt{2}} = \frac{T}{\sqrt{2}}$

FOR SECTION 2:

A length 3d' of the beam (in torsion)

This section is acted on by four forces, two positive at F and G and two negative −P at E and −P at H.

(1) Moments about CD causing rotation perpendicular to CD.

$$= P(\text{at } F) \times \frac{2d'}{\sqrt{2}} - P(\text{at } E)\frac{d'}{\sqrt{2}} = \frac{Pd'}{\sqrt{2}} = \frac{T}{\sqrt{2}}$$ *as for the central section 1.*

(2) Moments about any intermediate line ($C_1 D_1$) parallel to CD between A and B distant x from EA:

$$M = P\left(\frac{d'}{\sqrt{x}} + x\right) - Px = \frac{Pd'}{\sqrt{2}}$$ *as for the diagonal CD.*

There is therefore a uniform moment of $\frac{T}{\sqrt{2}}$ *producing a uniform tensile stress in the binding from A to B (as the binding resists the tensile stress and the tensile strength of the concrete is neglected).*

In a similar manner it can be shown that where the binding crosses the short side b' of the girder the moment resisted by the diagonal wire is $\frac{P'b'}{\sqrt{2}} = \frac{T}{\sqrt{2}}$ *and is uniform along the diagonal.*

To show why the assumption was made that the maximum stress in the binding is √2 times the average stress.

As b' is assumed to be the breadth of the shorter side, the stress in the wire at the longer side is greater than at the shorter side and the wire graduates from a maximum at the centre of the longer side to a minimum at the centre of the shorter side. The maximum stress is assumed to be :-

$t_{max} = \frac{T}{\sqrt{2}\,b' A_b}$ *and* t *average* $= \frac{1}{2}\left(\frac{T}{\sqrt{2}b'A_b} + \frac{T}{\sqrt{2}d'A_b}\right)$ *and* $\frac{t_{max}}{t_{avg}} =$ *(after cancelling out and reducing)* $\frac{2d'}{b'+d'}$.

Thus for a range of values $d'/b' = 1$ *to* $d'/b' = 5$

$d'/b' =$ 1	2	3	4	5
$\frac{t_{max}}{t_{avg}}$ 1	1·33	1·5	1·6	1·66

Thus the arithmetical mean of these five values (the common range in practice) $= \frac{7{\cdot}09}{5} = 1{\cdot}418 = \sqrt{2}$ *very nearly.*

This formula is only a design formula and is to cover, with a safety margin, many possible variations in construction, concrete mixtures etc. Other formulae with varying constants for the range of d'/b' from 1 to 5 could be used if desired. There is, according to Marshall and Tembe ("Structural Engineer," November 1941) a factor of safety of 4 on the ultimate steel stress for Rausch's formula, so that there is an adequate safety margin.

Design of a Bow Girder. *(See facing page.)*

Cooling Concrete in a Dam.

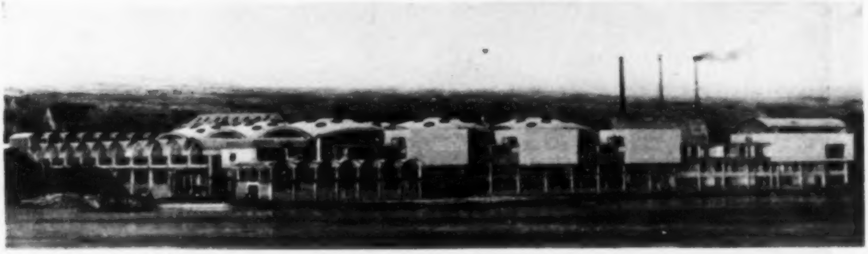
A DAM now being built at Warragamba, New South Wales, Australia, will be 1300 ft. long and 350 ft. high and will contain 1,500,000 cu. yd. of concrete which it is planned to place at the rate of 2000 cu. yd. per day. The dam is a straight gravity structure, and will have longitudinal and transverse construction joints at intervals of 50 ft. The structure will thus comprise a number of independent prisms which will be grouted together later. According to the "Commonwealth Engineer" for June, 1951, from which the following is abstracted, this form of construction has been adopted to avoid cracking in the concrete due to heat generated during the hydration of the cement.

A system of cooling pipes will be embedded in the concrete, and chilled water will then be circulated through the pipes to bring the concrete to its final temperature. To supplement the cooling pipes the temperature of the concrete will be maintained at 55 deg. F. when it is placed. During the summer most of the mixing water will be added in the form of ice and the remainder will be chilled to 34 deg. F. The maximum ice content will be 132 lb. per cu. yd. of concrete. The concrete will contain stones up to 6 in. maximum size and have a water-cement ratio by weight of 0·58. A plant capable of producing 170 tons of ice and 10,000 gallons of water per day at 34 deg. F. will be used. The ice must be of such size and shape that it can be readily conveyed and weighed and it must be small enough to fragment and thoroughly melt during the three minutes' mixing period. Also, it must be possible to alter the output quickly to suit the rate of placing concrete.

A contract has been awarded to J. Budge Pty., Ltd., and the H. Vogt Machine Co. of the U.S.A. for a refrigeration plant to cost about £90,000, and the plant was expected to be in operation early in 1952. Three tube-ice machines will be installed. The ice will be first produced in the form of hollow tubes having a wall thickness of ⅜ in., which will be crushed into segments about 1 in. long. The machines will be housed in a tower adjacent to the concrete mixers. As the ice is produced it will fall into hopper-bottomed storage bins capable of storing 60 tons of ice, from whence it will be taken by a screw conveyor to the mixing tower where it will be automatically weighed and emptied into the concrete mixer.

A water cooler of 4500 gallons capacity will be installed to deliver water at 34 deg. F. to the concrete mixer and the ice machines.

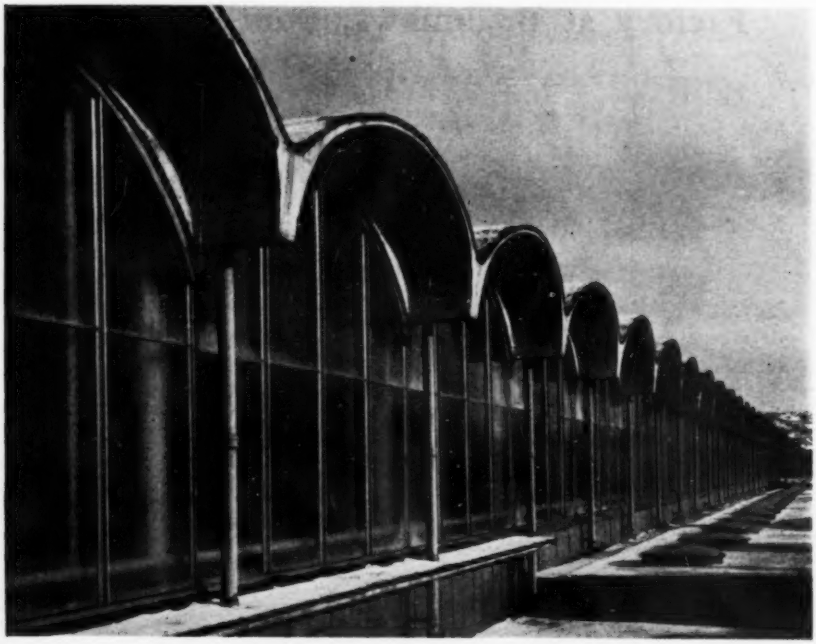
Factory at Brynmawr, South Wales.



VIEW FROM THE SOUTH.

THE MAIN PRODUCTION AREA.
(A DETAIL OF THE COLUMNS SUPPORTING THE DOMES IS GIVEN ON PAGE 154.)

ON this and the following pages are given some photographs of the factory for the Brynmawr Rubber Co., Ltd., which is now completed. The structure was illustrated and fully described in this journal for September 1949, when it was under construction. The main building covers an area of 325 ft. by 450 ft., and is notable for the free use of thin barrel-vault roofs and thin "shell" domes. The floor of the main building is of flat-slab construction, the columns of which are carried on piles. The Architects' Co-operative Copartnership were the architects, and Messrs. Ove Arup & Partners the consulting engineers. The foundation work was carried out by the Cementation Co., Ltd., and the remainder of the work was done by Messrs. Gee, Walker and Slater, Ltd., and Messrs. Holland & Hannen and Cubitts, Ltd.



The Upper Floor of the Drug Room.

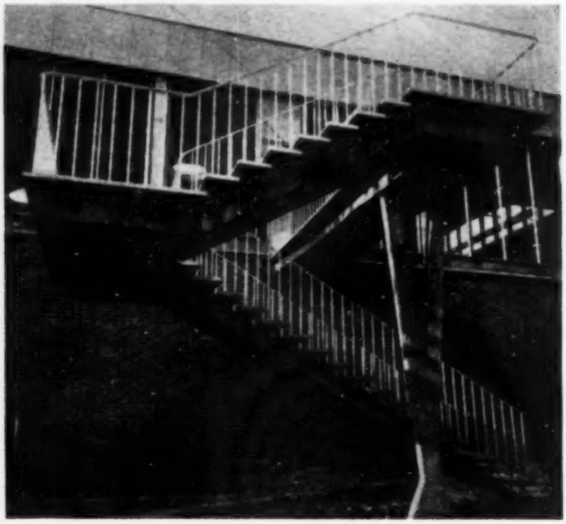
Interior of Drug Room.

Factory at Brynmawr, South Wales. (*See p.* 151.)

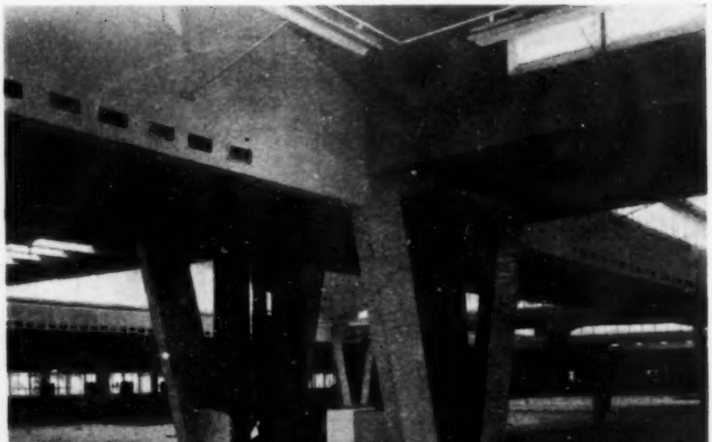
END OF RAMP AT MAIN ENTRANCE.

RAMP TO MAIN ENTRANCE.

Factory at Brynmawr, South Wales. (*See p.* 151.)



AN ESCAPE STAIRCASE.



RAKING COLUMNS AT INTERSECTION OF DOMES, AND SERVICE PIPES RISING TO OVERHEAD DUCTS.

Factory at Brynmawr, South Wales. (*See p.* 151.)

Consolidation of Concrete in Roads and Runways.

THE method of consolidating the concrete in the runway at the Munich-Riem airport in Germany is described by Ing. W. Tzschentke in "Strasse und Autobahn" for August 1951. The slab is 12 in. thick, and in parts 16 in. thick. At first the concrete was laid in three layers of 4¾ in., 4¾ in., and 2½ in., but this method required three sets of concrete mixing and placing plants, and there was a considerable interval between the laying of the bottom course and the completion of the joints in the top course. Also, the compacting of the lower layers was hindered by the joints and dowels which occurred at intervals of 25 ft. because the screed and vibrating tamper had to be lifted at each joint and lowered again beyond, and the concrete near the dowels had to be separately compacted. The compaction of the concrete in two layers each of 6 in. could not be carried out as the reinforcement was to be 2½ in. below the upper surface.

Fig. 1.

The slab was laid with a bottom course of 9½ in., on which the reinforcement was placed, and a top course 2½ in. thick. The slab was 25 ft. wide. The lower course was compacted with vibrators of the poker type, which were pulled through the concrete. Vibrators with a frequency of 9000 vibrations per minute were used, and it was found possible to achieve complete compaction to a depth of 9½ in. For this purpose, the vibrators were set 2 ft. apart and 1 ft. from the edge of the longitudinal joint, so that there were six vibrators over a width of 12 ft. 6 in. The

Fig. 2.—Vibrators Suspended from Bridge over Road.

leads to the vibrators and the transformer were mounted on a movable cradle on a carriage 25 ft. wide moving on rails. The advantage of the movable cradle was that, by moving the cradle across the width of the 25 ft. wide runway, the work could be done by six vibrators covering 12 ft. 6 in. The compaction of the lower course of one of the four runways was successfully done by three passages of the machine with the vibrators at different depths each time. For the construction of a runway 25 ft. wide only the following were necessary: 1 mixer for the bottom course, 1 spreader, 1 carriage with a movable cradle and six vibrators, and 1 mixer, 1 spreader, and 1 finisher for the top course.

This use of internal vibrators necessitated a wetter concrete than usual. The water-cement ratio for the lower course was increased from about 0·44 to 0·48, and this concrete could, after the passage of the vibrators, be walked on without noticeable marks remaining on the surface. The speed of compaction was about 1 yard per minute; the two courses were therefore compacted at the rate of about 1 yard in two minutes. Including the compaction around the dowels at the joints and changing for the forward and backward passes the position of the cradle carrying the vibrators, the average time of construction was between 6 and 7 minutes per yard. Cores cut from the runway showed that the bond between the two courses was good.

The vibrators had at first a tendency to work to the surface, and three men each looked after two vibrators and kept a distance of 2 ft. between them (*Fig.* 1). In future provision is to be made for a suspension mechanism on the cradle to keep the vibrators at a constant depth and spacing, so that the vibrators as well as the cradle and stage can be looked after by one man (*Fig.* 2).

The surface of the bottom course was smooth and the reinforcement was placed directly on it. The top course $2\frac{1}{2}$ in. thick was finished by a high-frequency vibratory screed.

Steel Removed from Prestressed Piles.

EXPERIMENTS have been made by a firm of contractors, Ben C. Gerwick, Inc., of San Francisco, on the possibility of driving prestressed concrete piles and removing the steel in cases where the piles will not be subjected to bending stresses when they are in place. The following notes on the experiment are from "Engineering News-Record" for January 10, 1952.

The test piles were 18 in. by 18 in. in cross section. The length is not stated, but from a photograph they appear to be about 30 ft. long. A test pile was prestressed with four 1-in. diameter mild steel bars which were placed loosely in metal or paper sleeves cast in the concrete. Threaded ends of the bars projected at each end of the pile and were fitted with plate washers and nuts. When the concrete had reached sufficient strength the nuts were tightened by a wrench to produce in the concrete a compressive stress of 136 lb. per square inch. This pile was lifted by attachments at three points in its length and driven to refusal.

A similar pile was lifted at a single point 9 ft. from the end. In this case the bars were tensioned to produce a compressive stress in the concrete of only 82 lb. per square inch. In neither case did any cracks appear in the piles while they were lifted. The concrete was in the proportions of 560 lb. of cement per cubic yard, and the compressive strength at 28 days was from 3500 to 4500 lb. per square inch. A wooden cushion, in which the protruding ends of the prestressing bars fitted, was used at the top of the piles.

When the piles were driven, the nuts were removed at the top end of the bars. The ends of the bars above the threaded part were of square section so that a spanner could be used to turn the bars and release them from the nuts at the bottom of the pile. The only steel left in the ground were the nuts and washers at the bottom of the piles. No mention is made of the shape of the lower end of the pile, or of whether a shoe was used.

A German Method of Shuttering.

A METHOD of composite steel and wooden shuttering, devised by A. Gattner and described in a recent number of " Beton- und Stahlbetonbau ", is illustrated in *Fig.* 1, in which the shuttering is applied to (A) floors, (B) columns, and (C) walls.

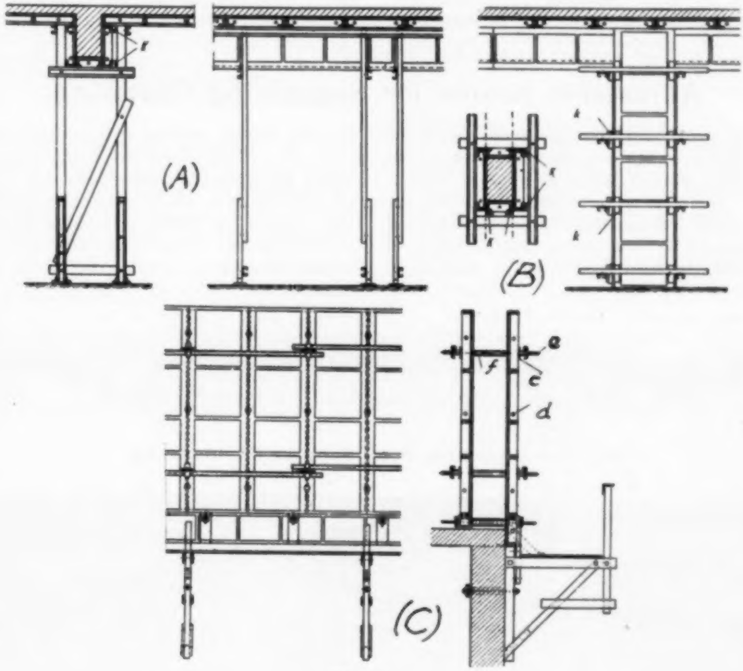


Fig. 1.

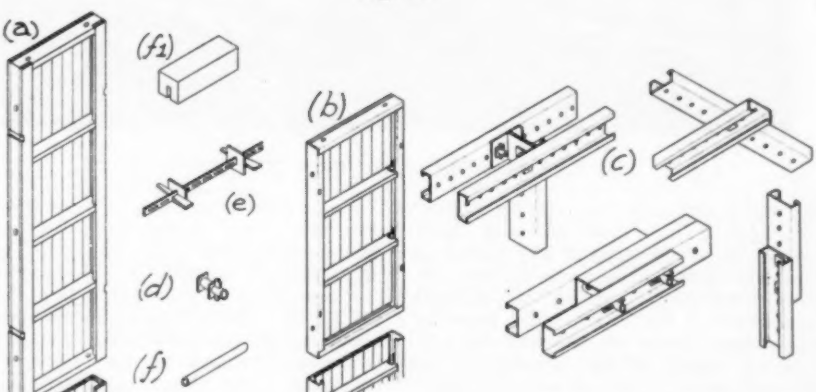


Fig. 2.

Details are shown in *Fig.* 2. The panels comprise wrought timber boards attached to a timber frame as at (*a*) or to a light steel frame as at (*b*). Shaped steel bearers and posts, shown at (*c*), are perforated at close centres to enable the shuttering to be used for members of different sizes. Timber wedges (*k*) are used. The parts are fixed together by tubular cotter-bolts (*d*) and wedged clamps (*e*) used in conjunction with steel spacers (*f*) or concrete spacers (*f*1). The shuttering is made by Siemens-Bau-Union.

Adjustable Beams for Supporting Centering.

A NEW type of adjustable steel beam for supporting centering for concrete floors and roofs is illustrated in *Figs.* 1 and 2. Each beam (*Fig.* 1) comprises one or more short lattice members and two end bearers. The lattice members are of three lengths, namely 2 ft. 0½ in., 3 ft. 1 in., and 4 ft. 1¼ in. The end bearers are adjustable and are of two lengths, namely 1 ft. 7½ in. to 2 ft. 1 in., and 2 ft. 0½ in. to 2 ft. 9¼ in. A beam of any length up to about 27 ft. can be made up by combining members of various lengths, final adjustment of the length being made by the sliding straps on the end bearers. The top flange of the members is an inverted pressed-steel channel generally 6 in. wide. The bottom boom of the lattice members is a steel tie-rod. The members are connected by butt-joints in the top flange and by turnbuckles on the tie-rods. Tightening the turnbuckles enables an upward camber to be formed on the beam so that, when the weight of the centering and wet concrete and constructional loads is imposed, the beams straighten and a flat soffit is obtained.

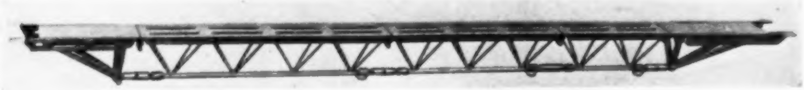


Fig. 1.—Adjustable Steel Support for Centering.

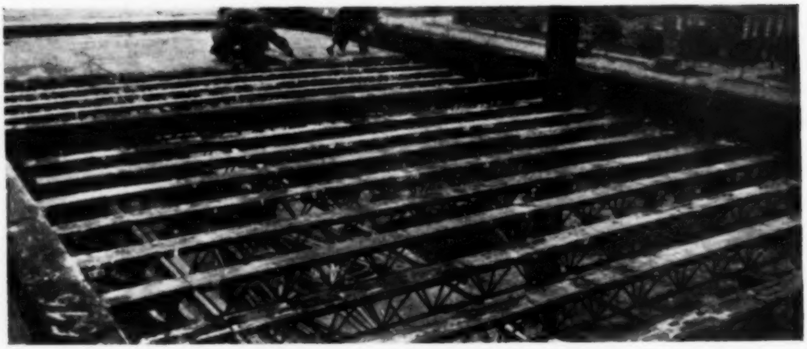


Fig. 2.—Fixing Centering Plates on Supports.

Fig. 2 shows these beams bearing on a structural steel frame and supporting steel centre plates. The beams can also be used with wooden sheeting and for the temporary support of hollow clay-tile floors. The weight of the beams is about 25 lb. per yard. Tests made in Germany show that the safe moment of resistance of the beams is about 39 tons-inches and the safe load on a standard end bearer is about 1 ton. The beams are supplied by Blaw-Knox, Ltd.

MISCELLANEOUS ADVERTISEMENTS.

Situations Wanted, 3d. a word : minimum 7s. 6d. Situations Vacant, 4d. a word : minimum 10s. Other miscellaneous advertisements, 4d. a word : 10s. minimum. Box number 1s. extra. The engagement of persons answering these advertisements is subject to the Notification of Vacancies Order, 1952.

Advertisements must reach this office by the 23rd of the month preceding publication.

SITUATIONS VACANT.

SITUATIONS VACANT. Reinforced concrete designers wanted for Southern Rhodesia and Union of South Africa. Candidates should have had at least 5 years' experience of competitive designing. Free passages. Salary according to experience and qualifications. Details in confidence to Box R13, c/o 95 Bishopsgate, London, E.C.2.

SITUATIONS VACANT. Civil engineer with first-class experience in design of heavy foundations and all types of reinforced concrete structures required for senior appointment with consulting engineers in Newcastle-upon-Tyne area. Applications are also invited for several posts for designer-detailers from applicants having previous experience in design and detailing of similar works. Salaries commensurate with qualifications and experience. Apply, giving particulars of age, experience, and salary required, to Box 2545, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. The Trussed Concrete Steel Co. Ltd., Truscon House, 35-41 Lower Marsh, London, S.E.1, require additional staff in their London and Manchester design offices: (*a*) Designer-Detailers (age 25 or over), (*b*) Detailer-Draughtsmen (age 20 or over). Previous good experience in reinforced concrete drawing office is important. Five-day week and pension scheme. Apply in writing to the above address giving full particulars of age, education, and previous employment.

SITUATION VACANT. Deputy to chief engineer in Manchester office of reinforced concrete specialists. Must be competent competitive designer, and capable of effective supervision of drawing office staff. Address applications in writing stating age, salary required, and particulars of career to date, in confidence, to Box 2546, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Civil engineer (qualified), with practical experience of reinforced concrete construction and design, required by old-established British firm in Pakistan. Terms—three years' agreement, free passage, and salary up to 2,000 Pakistan rupees (equivalent £216) per month according to experience. Single man age 30/35 preferred. Apply, stating full details, to Box 2547, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Water engineer required to design water supply schemes for North Borneo, including pumping, treatment, and distribution. The projects will be prepared in Singapore, and it is probable that the engineer appointed will be asked to supervise construction in Borneo. Please write to Box AP/2, c/o 95 Bishopsgate, London, E.C.2, for further information, and give details of career.

SITUATIONS VACANT. Reinforced concrete designers and detailers. Simon-Carves, Ltd., require reinforced concrete designers and detailers for industrial work. Excellent working conditions, and good scope. A pension fund and D.O. bonus scheme are in operation. Ministry of Labour permission will be necessary before engagement. Applications should be sent to Staff and Training Division, PERSONNEL DEPT. (Ref. Z.29), SIMON-CARVES, LTD., Cheadle Heath, Stockport.

SITUATION VACANT. Reinforced concrete. Deputy required to head of design department of well-known company of reinforced concrete specialists. Applicants must be University graduates or equivalent and/or corporate members of Institution of Civil or Structural Engineers. Administrative ability and first-class experience in design of all kinds of reinforced concrete structures essential. Preferred age 35/45. Write, giving age, education, qualifications, experience, and salary, to Box C.E. 121, at 191 Gresham Street, London, E.C.2.

SITUATIONS VACANT. Two structural draughtsmen with experience in reinforced concrete detailing required in London office of Norman & Dawbarn, architects and consulting engineers, 5 Gower Street, London, W.C.1. Reply stating age, experience, and salary required.

SITUATIONS VACANT. Architectural assistants. Simon-Carves, Ltd., have several vacancies for architectural assistants interested in reinforced concrete industrial structures. The main fields covered are coal preparation plant, coke ovens, chemical plant, and power stations. The work offers excellent experience and scope. A pension fund and D.O. bonus scheme are in operation. Ministry of Labour permission will be necessary before engagement. Applications should be sent to Staff and Training Division, PERSONNEL DEPT. (Ref. Z.B.36), SIMON-CARVES, LTD., Cheadle Heath, Stockport.

NORTH THAMES GAS BOARD.

There are vacancies in the Chief Engineer's department for the following draughtsmen: (i) WESTMINSTER, S.W.1, experienced in any of the following: Coal carbonising plant, by-products plant, steel structures, pipe layouts, or materials handling plant. (ii) BROMLEY-BY-BOW, E.3, preferably experienced in the maintenance of gas plant and conversant with the design of steel structures and the layout of buildings. Starting salary, depending on age and qualifications, will be within the range £595–£725 per annum, and the appointments will be of a permanent nature after a probationary period. Pension arrangements will be discussed with short-list candidates. Applications, giving age and full particulars, should be sent to the Staff Controller, North Thames Gas Board, 30 Kensington Church Street, London, W.8, quoting reference 666/26, to reach him not later than 10 days after the publication of this advertisement.

SITUATION VACANT. Reinforced concrete designer required for Westminster office of civil engineering contractors. Applicants must have experience in competitive designs of industrial buildings, foundations, and marine structures. Apply stating age, experience, and salary required. Box 2549, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. The British Reinforced Concrete Engineering Co., Ltd., require several qualified designers with specialist experience for their Stafford, London, Bristol, Glasgow, and Newcastle-upon-Tyne offices. Five-day week, and staff pension scheme. Apply to B.R.C. ENGINEERING CO., LTD., Stafford.

SITUATION VACANT. Senior civil engineering draughtsman required in a large London concern. Candidates should have recent practical experience in design, construction, and detailing of reinforced concrete industrial buildings, structures and foundations, and some knowledge of structural steel work design. A good knowledge of structural theory is essential. Write, stating age, full details of qualifications, and previous experience (with dates), and salary required, quoting this paper, to Box No. 2550, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1. Original testimonials should *NOT* be forwarded. Closing date, 26 May, 1952.

SITUATION VACANT. The Trussed Concrete Steel Co., Ltd., require an engineer for site inspection of the reinforced concrete work carried out by contractors to the Company's designs. Applicants should have held responsible positions as resident engineers or agents for reinforced concrete constructional work. Visits to sites in all parts of the country will be entailed. Some design experience is desirable. Write, giving details of age, experience, and salary required, to the SECRETARY, THE TRUSSED CONCRETE STEEL CO., LTD., Truscon House, 35/41 Lower Marsh, London, S.E.1.

(*Continued on page* liv.)

MISCELLANEOUS ADVERTISEMENTS.

(*Continued from page* liii.)

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

BURSARIES IN CONCRETE TECHNOLOGY

NOTICE IS HEREBY GIVEN that the election to Bursaries in Concrete Technology tenable as from October, 1952, will take place in June, 1952.

Candidates must hold a degree in engineering at the time of taking up the award, and must also have a good knowledge of the theory of structures.

Bursaries are of the value of £350 per annum, out of which the College Tuition Fee has to be paid; the amount may be increased to £450 for those with industrial experience. In addition, 1 or 2 Senior Bursaries of £600 per annum may be awarded to outstanding men with a minimum of 3 years' experience in industry.

The course will be postgraduate and Bursars who successfully complete the course will be eligible for the award of the Diploma of the Imperial College (D.I.C.).

Applications must be received on or before June 1st, 1952, by the DEPUTY REGISTRAR, CITY AND GUILDS COLLEGE, Exhibition Road, London, S.W.7, who will, on written request, send full information and application forms.

SITUATION VACANT. Reinforced concrete detailer required, with 4 to 5 years' experience, by consulting civil engineers. Chiefly water-containing structures. Five-day week; pension scheme. Salary according to experience. Write, giving age, etc., education, training and experience in chronological tabular form. Box 2551, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Qualified civil engineer is required by British firm of civil engineers and contractors operating in Malaya and Borneo as assistant to the contracts' manager. Previous experience as contractors' agent or sub-agent on works of some magnitude is essential. Age indication 35 to 30 years. Initial agreement for three years. Write with full particulars, personal and professional, to Box AP/136, c/o 95 Bishopsgate, London, E.C.2.

SITUATION VACANT. Trollope and Colls, Ltd., require immediately site engineer for concrete control. Must have experience of sampling and testing of aggregates, moisture content, and concrete mix design and control. Write Chief Engineer, 41 Great Queen Street, London, W.C.2.

SITUATION VACANT. Designing structural draughtsman required by large South London builders specialising in all types of housing work. Preferably member of Institution of Structural Engineers. Commencing salary up to £650 per annum according to experience. Apply Wates, Ltd., 1258–60 London Road, London, S.W.16.

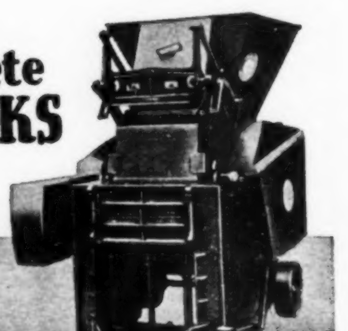
FOR SALE.

FOR SALE. Lister 10/7 concrete mixer for sale. F. J. EDWARDS, LTD., 359 Euston Road, London, N.W.1. EUSton 4681.

FOR SALE. Steel-angle fencing stakes, 54 in. by $1\frac{1}{4}$ in. by $1\frac{1}{4}$ in. by 14-gauge. Holes at 6-in. intervals; pointed and painted, at 2*s.* each, 50 lots; 1*s.* 11*d.* each, 100 lots; 1*s.* 10*d.* each, 1,000 lots; carriage paid. Other sizes available on request. E. STEPHENS & SON, LTD., 58/64 Bath Street, London, E.C.1.

EXCHANGE.

EXCHANGE. 3 tons mild steel reinforcing rods, 1 in. diameter or smaller, in exchange for equal weights of $\frac{3}{4}$ in. diameter "Isteg" reinforcing equivalent to $1\frac{1}{16}$ in. diameter plain round. Apply RIBAR, LTD., Higher Swan Lane, Bolton.



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